High Efficiency EUV Diffraction Gratings for Heliophysics

Completed Technology Project (2017 - 2019)

Project Introduction

We propose to advance the capability of diffraction gratings for high resolution imaging spectroscopy in the wavelength range 0.1-20 nm. While high resolution UV spectroscopy such as that provided by the Interface Region Imaging Spectrograph (IRIS) mission for wavelengths around 140 and 280 nm has demonstrated the need for high spatial and spectral resolution to understand the basic physical processes that energize the solar atmosphere, the hottest temperature lines that provide diagnostics of the most energetic solar eruptive events are predominantly at the much shorter EUV / Soft X-ray wavelengths of 0.1-20 nm. For example, the intrinsically strongest lines of highly ionized iron, Fe XVII–XXVI, which form at temperatures of 3 to 100 Million Kelvin, all lie in this range, providing the strongest lines for observing solar flares, and for testing impulsive heating theories (such as the nanoflare hypothesis) of how the solar atmosphere is energized. Regarding the effects that solar eruptive events have on the heliosphere, recent EUV imaging observations by the Solar Dynamics Observatory (SDO) when off-pointed from the Sun and by the PROBA-2 “Sun Watcher using APS and Image Processing" (SWAP) instrument have revealed that the extended corona can readily be observed in the EUV, contrary to the prevailing notion that this can only be done using visible light coronagraphs. Spectrally and spatially resolved observations of the extended corona in the 18-20 nm range, for example, would be able to track coronal mass ejections not only in the plane of the sky (as with visible light coronagraphs) but also their velocity along the line of sight. Understanding the heating of coronal plasmas and the effects of solar eruptive events on the heliosphere are at the heart of NASA's strategic goal to Understand the Sun and its interactions with Earth and the solar system. A diffraction grating is the critical optical element of an imaging spectrograph. Manufacturing a diffraction grating to perform with high efficiency and resolution for extreme ultraviolet (EUV) and soft X-ray light is technically very challenging owing to the high groove densities and stringent surface roughness requirements. Gratings can be manufactured holographically or mechanically. Currently, holographic gratings tend to have better surface roughness characteristics, while mechanically ruled gratings can provide higher groove densities and better (more efficient) blaze profiles. Mechanically ruled gratings will be able to provide better performance at lower cost if surface roughness issues are addressed; Techniques to address this issue include optimizing the deposition of the layer into which the grooves are ruled, and ion beam polishing. Another promising option is to use standard lithography techniques for silicon wafers on a custom-cut wafer with the atomic lattice aligned to the desired blaze angle. We will obtain test grating samples fabricated by these multiple options, deposit multilayer coatings tuned to the target EUV wavelengths of interest, and evaluate their performance in the EUV, in order to determine which will provide the maximum efficiency, and thus, will provide greater capability for future missions to address the science goals discussed above.

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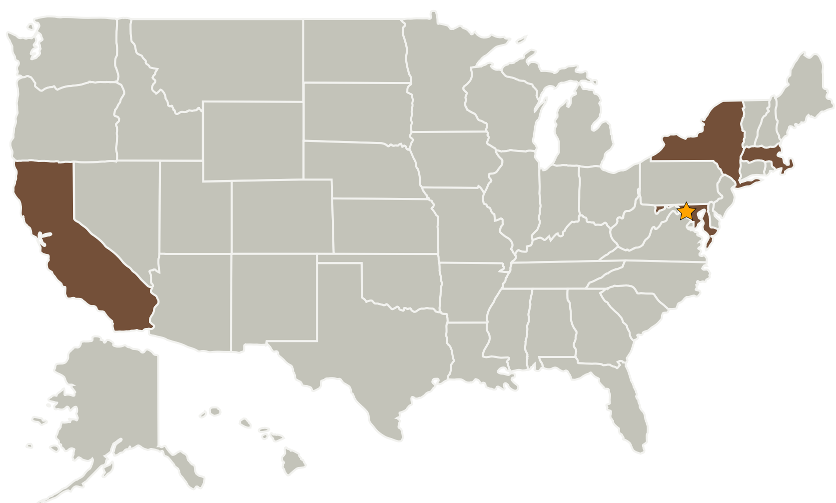
Anticipated Benefits

Support NASA's strategic objectives to understand the Sun and its interactions with Earth and the solar system, including space weather. This will be achieved by developing/demonstrating instrumentation technology necessary to address the following science goals:

- Explore the physical processes in the space environment from the Sun to the Earth and throughout the solar system;
- Advance our understanding of the connections that link the Sun, the Earth, planetary space environments, and the outer reaches of our solar system;
- Develop the knowledge and capability to detect and predict extreme conditions in space to protect life and society and to safeguard human and robotic explorers beyond Earth.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
☆Goddard Space Flight Center(GSFC)	Lead Organization	NASA Center	Greenbelt, Maryland

Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Center / Facility:

Goddard Space Flight Center (GSFC)

Responsible Program:

Heliophysics Technology and Instrument Development for Science

Project Management

Program Director:

Roshanak Hakimzadeh

Program Manager:

Roshanak Hakimzadeh

Principal Investigator:

Adrian N Daw

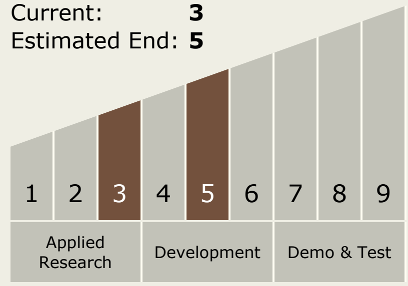
Co-Investigators:

Eric Gullikson
Peter Cheimets
Edward E Deluca
Jenna E Samra
David L Windt
David T Leisawitz

Primary U.S. Work Locations	
California	Maryland
Massachusetts	New York

Technology Maturity (TRL)

Start: **3**
Current: **3**
Estimated End: **5**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  └ TX08.1 Remote Sensing Instruments/Sensors
    └ TX08.1.1 Detectors and Focal Planes

Target Destination

The Sun